

Geologic Resource Assessments Subactivity

Subactivity	FY 2000 Estimate	Uncontrol. & Related Changes	Program Changes	FY 2001 Budget Request	Change from FY 2000
Mineral Resources	53,893	+1,193	⁽¹⁾ -2,000	53,086	-807
Energy Resources	22,783	+524	-2,009	21,298	-1,485
Total Requirements \$000	76,676	+1,717	-4,009	74,384	-2,292

¹ See Program Change section for details on Decision Support/Resource Management (+\$1,200) and program decreases (-\$3,200)

Mineral Resources

Current Program Highlights

Minerals and mineral products are important to the U.S. economy; processed materials of mineral origin accounted for an estimated \$415 billion (5 percent) of the gross domestic product in 1998. The USGS Mineral Resources Program (MRP) is the sole Federal provider of scientific information for objective resource assessments and unbiased research results on mineral potential, production, consumption, and environmental behavior. This information is used to characterize the life cycles of mineral commodities from deposit formation and discovery to mineral recycling. The MRP continues to increase the availability and usefulness of its data resources by designing and implementing methods for integrating and delivering spatially referenced digital data via the Internet using standard World Wide Web technology and software. Analyses based on these data are critical to the formulation of economic and environmental policy and also provide land managers with decision options when there are conflicting demands for resources.

Environment and Public Health -- Environmental effects of mineral deposits that result from natural processes, mining, and mineral processing are key issues in national and global mineral-resource development. The abundance, compositions, and environmental availability of minerals or their contained elements in rocks and soils define the geochemical landscape and directly influence nutrient availability, toxic element concentration, vegetation distribution, and the general health of ecosystems. The MRP conducts geologic, environmental, and public health studies in cooperation with land-management agencies, biologists, medical professionals, States, universities, and industry. MRP supplies objective information, research, and assessments that are used for prioritizing mitigation and restoration projects, developing mitigation and restoration strategies, and formulating regulatory policy. Current MRP activities include examining how minerals affect ecosystem health; assessing abandoned mine lands; characterizing the source, transport, and fate of toxic elements, particularly mercury and arsenic; and developing regional and national geologic, geochemical, and geophysical baseline and background maps and databases. Through the use of remote-sensing technologies such as imaging spectroscopy, developed by MRP with NASA, program scientists can map environmentally significant characteristics such as mineral alteration, mineral distribution, and vegetation health.

Sustainability and Societal Need -- As world population increases and the world economy expands, so does the demand for natural resources. As described by the National Research Council, ASustainability represents a growing concern about the adequacy of mineral resources to meet future demands and to do so without unacceptable environmental degradation.® The MRP maintains national databases, develops assessment and analysis methods, and conducts applied research that provides the objective scientific tools for decision-making related to sustainability. The USGS is a world leader in understanding mineral occurrences and developing methodologies for quantitative and qualitative mineral and environmental assessments. Mineral-deposit research provides the fundamental knowledge used to understand where minerals occur and how they interact with the environment. Understanding the origin of mineral deposits and developing genetic components of mineral-deposit life cycle models are fundamental requirements for construction of accurate deposit models and for adequate assessment of the Nation's mineral resources. Concepts of ore genesis evolve over time as our understanding of geologic and ore-forming processes increases, as new deposit types are recognized, and as technology advances. USGS assessments of the distribution, economic significance, and environmental impact of development of the Nation's mineral resources are conducted on regional, national, and global scales to meet the needs of land-management agencies and national policy makers. In response to the need to update and maintain urban infrastructure, the MRP is increasing its emphasis on assessments of aggregate resources, such as sand, gravel, and crushed stone. Current program activities include development of environmental models, economic filters, materials flow models, and assessment techniques for selected industrial minerals. In the last four years, MRP has focused on electronically disseminating the national and regional databases of geochemistry, geophysics, mineral and mine localities, and lithology, as well as the extensive science applications developed using these data. We are actively working with our partners on developing an interactive geospatial information system that will be made available on the World Wide Web.

Economy and Public Policy -- The MRP responds to the economic and public policy needs of the Nation by providing long-term national and regional data on mineral potential, production, use, and recycling to land-management agencies, regulatory agencies, industry, academia, and the public. MRP collects, analyzes, and disseminates information on the production and consumption of about 100 mineral commodities, both domestically and internationally for approximately 190 countries. Information on strategic minerals is provided to the Department of Defense for managing the National Defense Stockpile. By monitoring the flow of materials through society, MRP provides information and analyses essential for sustainability indicators, as well as for mineral conservation and recycling, land stewardship, and environmental policy for governments, industry, and the public. Government agencies, financial institutions, and many types of industries use MRP's monthly metal industry indicators to monitor the health of the U.S. metal industries. Current activities include projects in National Parks, National Forests, and BLM Resource Areas that provide geospatial minerals, geologic, geochemical, and geophysical information for land stewardship and management plans; national geospatial databases that allow rapid response to land management concerns; materials flow analyses of key minerals in the economy and environment; and minerals information on over 100 commodities on a monthly, quarterly, semi-annual, and annual basis. In the last four years, the program has focused on electronically disseminating national and regional databases of geochemistry, geophysics, mineral and mine localities, and lithology, as well as the extensive science applications developed using these data. The USGS is actively working with partners to develop an interactive geospatial information system that can be served on the World Wide Web, and will assist land managers and policymakers with analysis of natural resources and the potential environmental effects of resource utilization.

Technology and Information Dissemination -- USGS minerals research results are available to users in easily accessible, accurate, and timely products. Information is disseminated through traditional paper products, in digital form, over the Internet (<http://minerals.usgs.gov/>), by FAXBACK (703-648-4999), through interagency collaborations, and in technical and non-technical public presentations. Geospatial data are a major component of this theme, as is dissemination of timely information about MRP activities and accomplishments. Other components include development of new geophysical and geochemical techniques for mineral-resource studies and the application of mineral-resource expertise and techniques to other societally relevant issues such as mapping earthquake and volcanic hazards, location and evaluation of energy resources, characterization of hydrology, or location of buried ordnance.

Partners -- All projects in the program are enhanced by working with partners in other Federal, State, and local agencies, universities, or industry. Over half of the studies conducted have an environmental component and over half of the projects are providing direct scientific support to land management and regulatory agencies. Collaboration with other Federal and State agencies focuses on meeting information needs concerning the lands they administer, including a wide range of topics from land management plans to characterizing Superfund sites. Through university cooperative agreements, the program partners with academia and industry to conduct basic research on ore forming processes and surficial geochemical processes in order to understand the environmental consequences of deposit weathering, extraction, and use. Through an extensive network of over 18,000 industry and State collaborators, the program synthesizes and disseminates high quality national and international production data that are useful to policymakers, land managers, industry, environmental community, regulators, economists, and educators.

Recent Accomplishments

Land management decisions and economic development in southeast Alaska -- USGS research has provided a basis for interpretation of geophysical surveys in Tongass National Forest, southeast Alaska, which were supported by federally appropriated funds to Bureau of Land Management (BLM) and the City of Wrangell. Field and laboratory studies conducted in cooperation with the BLM, USDA-Forest Service, Alaska Division of Geological and Geophysical Surveys, and City of Wrangell improved the basis for mineral assessment of these Federal lands, provided information to the Forest Service for updating their land management plans, and provided a foundation for industry to undertake efficient and competitive mineral exploration in the area. USGS identified a larger area prospective for mineralization than previously known, as rock units that host numerous mines and mineral deposits in the southeastern Alaska, including the Greens Creek mine and the Windy Craggy prospect, are exposed over a broader area than previously thought. Results of this project include digital versions of the updated geologic map and resource assessment of the project area; new geophysical, geochemical, structural, and isotopic data compilations; and interpretive reports released on CD-ROM and via the World Wide Web. Results were presented to the annual meeting of the Alaska Miners Association.

Understanding basin formation in the arid southwest -- USGS scientists are integrating new and existing geologic, geophysical and geochemical data and imagery to provide three-dimensional visualizations of the upper Santa Cruz River, Tucson, and San Pedro River basins, southeastern Arizona. The result of this is an integrated model of basin formation in the arid southwest which provides information for land and water utilization strategies in these basins and can be used as a starting point for detailed study of other basins. Analysis of the geologic

and geophysical logs of two deep wells, one in the San Pedro and one in the Tucson basin, has provided a record of the basin-filling events which can be directly related to the detachment-tectonic events forming the basins. Using gravity and aeromagnetic data, the shape and probable composition of subbasins have been defined and a map of estimated thickness of the best aquifer in the basins produced. Analyses of data from airborne electromagnetic surveys are being used to model porosity and permeability in three dimensions, permitting construction of water quality and quantity models of unprecedented resolution. Further studies of the electromagnetic data have shown extensions of known mineral districts beneath the edges of the basins; providing information valuable both for predicting water quality and for mineral resource exploration. As rapid urban development continues in the arid southwest, understanding how the landscape formed and where good quality waters is likely to be available will be increasingly important for effective planning.

U.S. aggregates and clay operations map -- USGS scientists have prepared a map showing accurate locations of most active commercial sand and gravel, crushed stone, and clay operations in the United States—about 8,600 locations. USGS coordinated the participation of the State geological surveys to verify the data and ensure the highest quality of information possible. The final USGS aggregates and common clay databases, including recent updates, are being incorporated in the National Atlas of the United States. The preliminary map, *Natural Aggregate Operations, Commercial Producers*, has been displayed several national aggregates industry trade shows. The popularity and value of the aggregates information is reflected in the fact that the four-page USGS fact sheet on aggregates was updated and reprinted at the request of the Federal Government, State governments, and industry. These reprints were completed in cooperation with the Missouri Limestone Producers Association and fourteen other State Trade Associations.

Environmental consequences of mining in Fortymile River, Alaska -- A systematic water-quality study of the Fortymile River and many of its major tributaries in eastern Alaska was recently completed. This effort, in cooperation with the Alaska Department of Natural Resources and the U.S. EPA, sought to establish regional baseline geochemistry values for water, soil, and vegetation and to evaluate the possible environmental effects of suction dredge placer gold mining and of bulldozer-operated placer gold mining (commonly referred to as “cat mining”). In general, the water quality of the Fortymile River is very good, with low total dissolved solids and only two cases in which the concentration of any element exceeded primary or secondary drinking-water quality standards. In both cases, iron exceeded secondary drinking-water limits. At the time this work was conducted, only a handful of suction dredges were operating on the lower Fortymile River, and cat mining was being conducted along Uhler Creek and Canyon Creek, two major tributaries to the river. Based on the water-quality and turbidity data, the suction dredges have no apparent impact on the Fortymile River system, although effects on biota were not evaluated in this study. In contrast, the cat-mining operations in Canyon Creek appear to have a dramatic impact on water quality and streambed morphology, based on the field water-quality and turbidity measurements, on comparisons to adjacent unmined drainages, and on field observations of streambed morphology. The cat mining in Uhler Creek appears to have had less impact, perhaps because the main stream channel was not as heavily disrupted by the bulldozers, and the stability of the channel was mostly preserved.

Price Book -- In response to requests by the Bureau of the Census, the Bureau of Economic Analysis, and other Government agencies, as well as academia and others, USGS mineral commodity specialists have authored and published a special report, *Metal Prices in the United States through 1998*. This publication tracks long-term price trends for over 60 metals in current

and constant dollars (deflated in relation to the Consumer Price Index) and discusses significant events that influenced price changes. This information is used by Government agencies and others to analyze the contribution of the metals sector to the U.S. economy. The publication, available in printed and electronic form, updates a publication released by the U.S. Bureau of Mines in 1991.

USGS responds to mineral information needs in Alaska -- In response to a request from Congress, the USGS organized a diverse group of stake holders including other Federal Agencies, the Alaska Division of Geologic and Geophysical Surveys (ADGGS), the University of Alaska, Native Corporations, and the geologic community as a whole to improve the quality and accessibility of minerals information in Alaska. The results of this effort, started in FY 1998, are: digital cataloging of the 18,000-volume USGS Alaska library, historic holdings of the USGS Alaska Technical Data Unit, and BLM's Juneau Minerals Information Center; updating and posting mineral occurrence records for 50 1:250,000-scale quadrangles; correcting errors in records for 30,000 geochemical samples and posting the data on the Internet; completion of an 11,000 record geospatially referenced bibliography of maps and papers on Alaska; and providing support for publication of a Guide to Alaska Geologic and Mineral Information as ADGGS Information Circular 44. The guidebook contains information about the collections of seven libraries and archives in Alaska, as well as information about many other minerals-related subjects, and was featured at the Alaska Miners Association Convention and at an open meeting of the Alaska Land Manager's Forum. All of this information is available on the Internet at: <http://imcg.wr.usgs.gov>.

National Geochemical Database -- The USGS National Geochemical Database is a digital repository of about 70 million analytical determinations made on approximately two million samples of geologic material such as rocks, stream sediments, and soils. These data provide a varying degree of geochemical information for approximately two-thirds of the land area of the US. During FY 1999 and FY 2000 USGS scientists and data managers have made major improvements in the reliability and accessibility of this critical database. Original paper records have been scanned and organized into an historical archive, safeguarding against loss due to fire, theft, or other disasters. By mid FY 2000 all samples from Alaska that were analyzed in USGS labs (about 160,000 samples) will have been reviewed, corrected, and made available in the World Wide Web. An additional 92,000 samples from the Montana and Idaho have also been reviewed and updated. Samples collected by the National Uranium Resource Evaluation program in the late 1970s and early 1908s have been made available on the World Wide Web for all of 17 states and parts of four others.

Zinc-lead-silver potential in Alaska -- USGS scientists have produced a wealth of new data crucial for understanding the processes responsible for syngenetic massive sulfide deposits formation in three important metallogenic belts in Alaska: the northern Alaskan belt, including Red Dog, the world's largest zinc deposit, which accounts for almost half of the total annual value of Alaska's \$1 billion minerals industry; the southeastern Alaskan belt, including the Greens Creek deposit, the largest US producer of silver in 1997 and 1998; and east-central Alaska and western Canada, where new discoveries in Canada bring to light new potential in Alaska. Multidisciplinary studies in these three areas demonstrate that the deposits, while similar in gross characteristics, likely formed through substantially different combinations of geologic events. Delineating the critical events leading to zinc-lead-silver ore formation in these basins in Alaska should lead to better assessments of resource potential in Alaska, elsewhere in the US, and ultimately on a global scale, improving our understanding of the global resource base for zinc, lead, and silver.

New discoveries from the floor of Yellowstone Lake -- Recently completed high-resolution sonar imaging, seismic reflection, and magnetic surveys of the northern part of Yellowstone Lake show a bottom covered with dozens of circular depressions and hundreds of spires and pinnacles protruding from the floor. The circular depressions are 25-800 meters in diameter, have steep inner walls, and may be the remnants of explosive events similar to explosion craters exposed on land nearby. The spires are composed primarily of silica, are up to 35 meters high and 50 meters in diameter. These linear features may sit astride fissures on the lake floor. Formation of both spires and circular depressions is related to deep-seated fluid circulation in the Earth's crust and has occurred over the past 12,000 years. The spires in Yellowstone Lake are formed by venting processes similar to those that form black smoker chimneys on the ocean floor. Other features recognized in the survey conducted jointly by USGS, Eastern Oceanics, and the University of Wisconsin at Milwaukee include vents through which deep circulating fluids exhaust onto the lake bottom, recent faults, and submerged former shorelines. Further analysis of the data and additional investigations using a submersible, remotely operated vehicle may define the relationships between fluid circulating features and fish and other lake-dwelling fauna. Objectives of this work include understanding the geologic processes that shape the lake and how they affect present-day lake populations, as well as examining a modern analog for the deep-fluid circulation systems responsible for many important types of mineral deposits.

USGS scientists make major contributions to a new textbook on the environmental effects of mining -- Cleaning up the environmental impacts of past mining operations, as well as predicting and mitigating the potential environmental impacts of future mining operations, are high priorities of societies worldwide. Over 20 USGS scientists have played major roles (as lead editor and chapter authors) in the development of a new two-volume textbook, recently published by the Society of Economic Geologists, that will help improve mining-environmental prediction, mitigation, and remediation. The textbook, *The Environmental Geochemistry of Mineral Deposits*, uses a unique mixture of overview papers and case studies to provide a process-oriented, interdisciplinary understanding of the environmental and health effects of mineral resource development, as well as of the scientific methods used to assess these effects. The text is geared toward geologists, mining engineers, environmental regulators, environmental scientists, land managers, students, and others who need to understand the scientific processes behind mining-environmental issues.

Arsenic in the Southern Appalachian Basin -- The highest reported arsenic and fluorine concentrations for all US coals, as well as elevated levels of mercury, copper, molybdenum, thallium, and antimony and gold, are found in coals from the Warrior Basin, Cahaba and Coosa basins, northern Alabama. Arsenic ranges up to 2300 parts per million (ppm whole coal). On average, arsenic in Alabama coals is three times higher than other U.S. Coals. These conclusions are based on nearly 1000 coal analyses contained in the USGS National Coal Resources Database, and on additional new data now being obtained by USGS scientists. These ongoing studies have revealed that the arsenic, copper, molybdenum and thallium and gold are contained in the mineral pyrite. Arsenic is also enriched in other portions of northern Alabama. Arsenic, antimony, and copper are common in small gold deposits in metamorphic rocks located east and southeast of the Warrior coal basin. The arsenic and associated elements were likely introduced into the coal by the same fluids that formed the gold deposits further east. The presence in northern Alabama of elevated arsenic concentrations in multiple geologic settings raises the possibility of widespread dispersion of arsenic into the environment. Stream sediments from the coal mining area are elevated in arsenic compared to adjacent areas and arsenic concentrations as high as 200 ppm have been measured in streams receiving coal acid mine drainage. Stream sediments near arsenic-enriched gold mines have

elevated arsenic concentrations compared to non-mineralized areas. Follow-up studies are planned to establish the extent and environmental impact of this seemingly widespread arsenic enrichment.